A conceptual understanding of the subsurface redox architecture

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March. 6. 2019 ATV meeting

MapField

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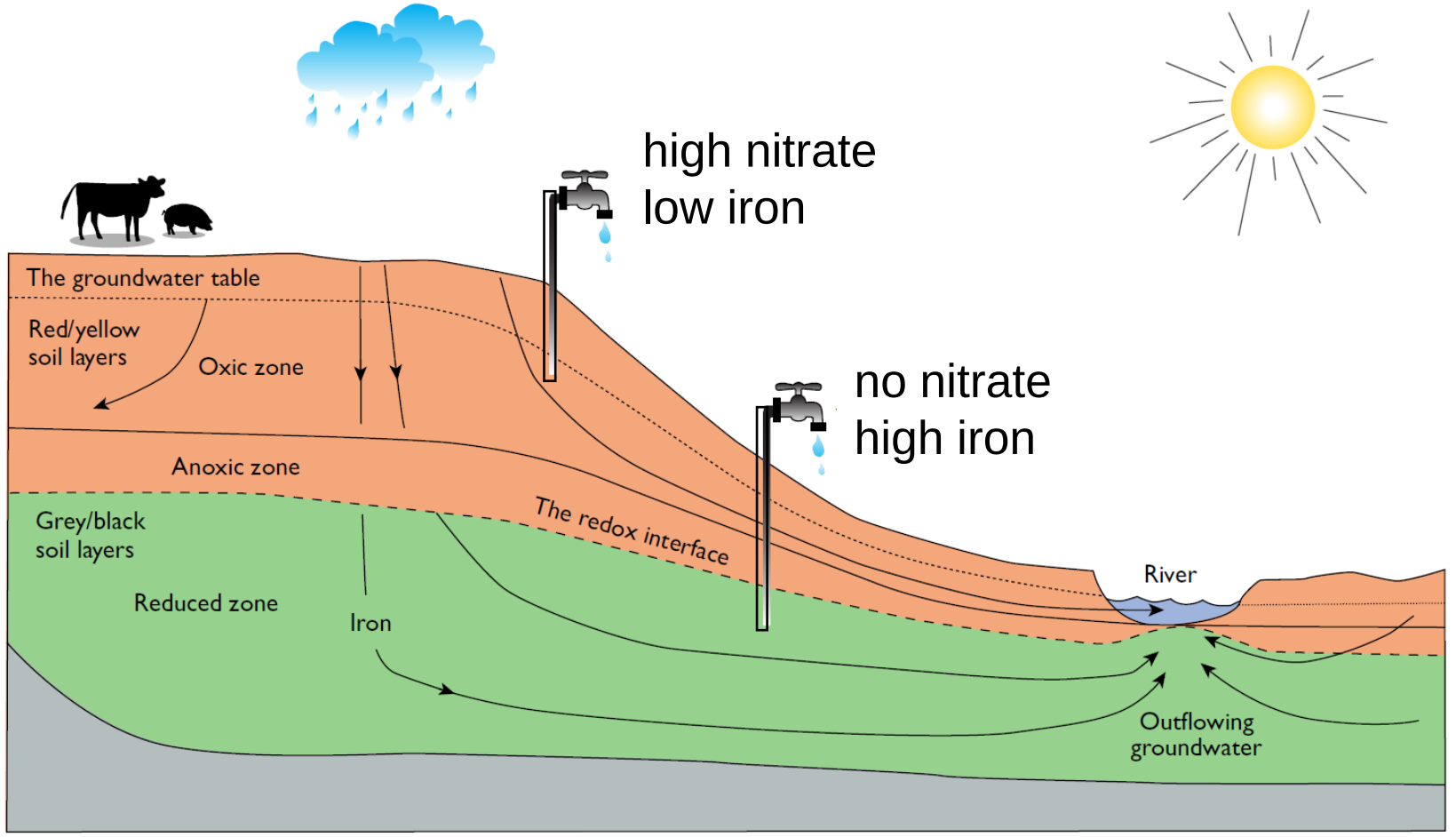
A ‘textbook’ model of the subsurface redox environment



Hansen et al. (2012)

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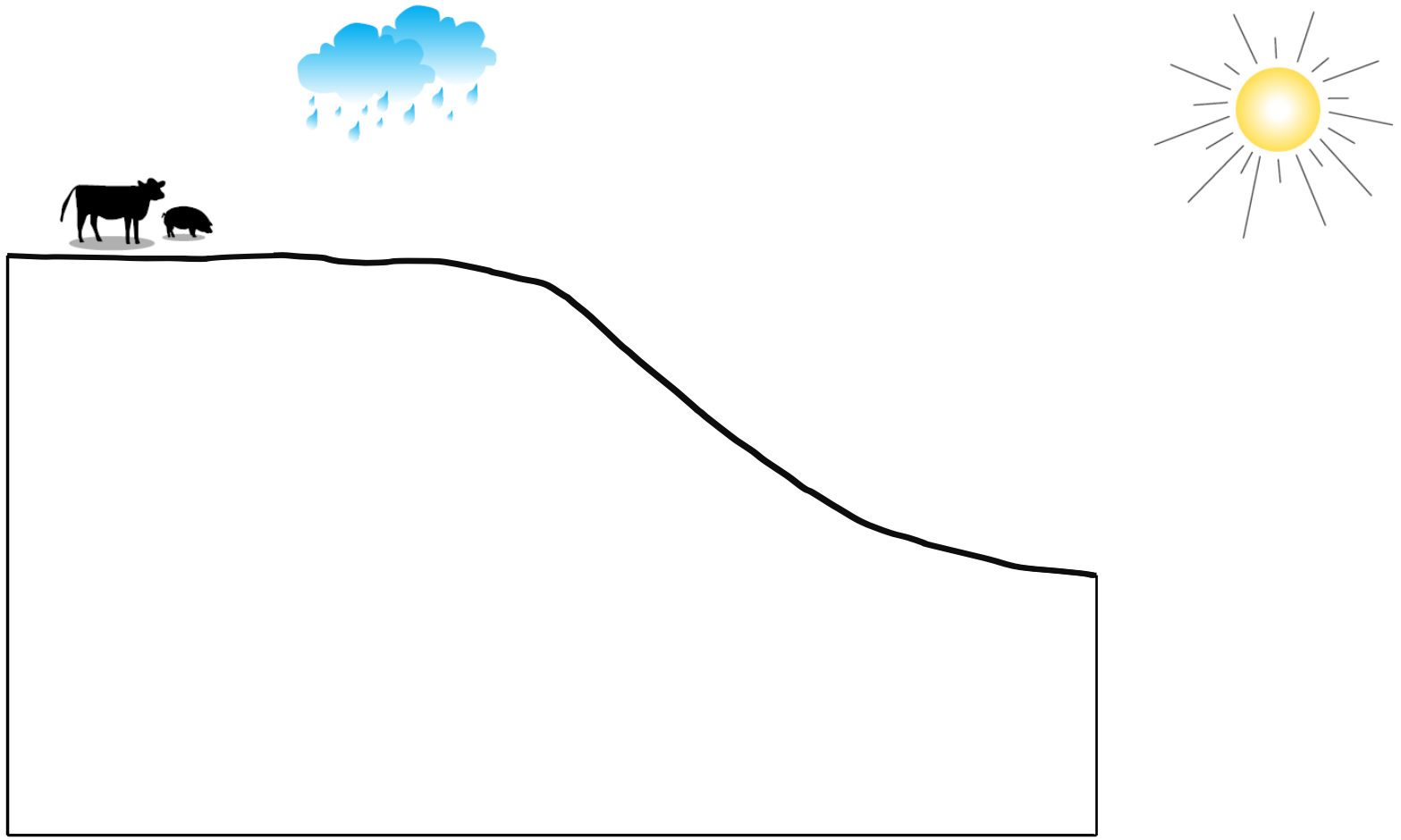
In an idea world…



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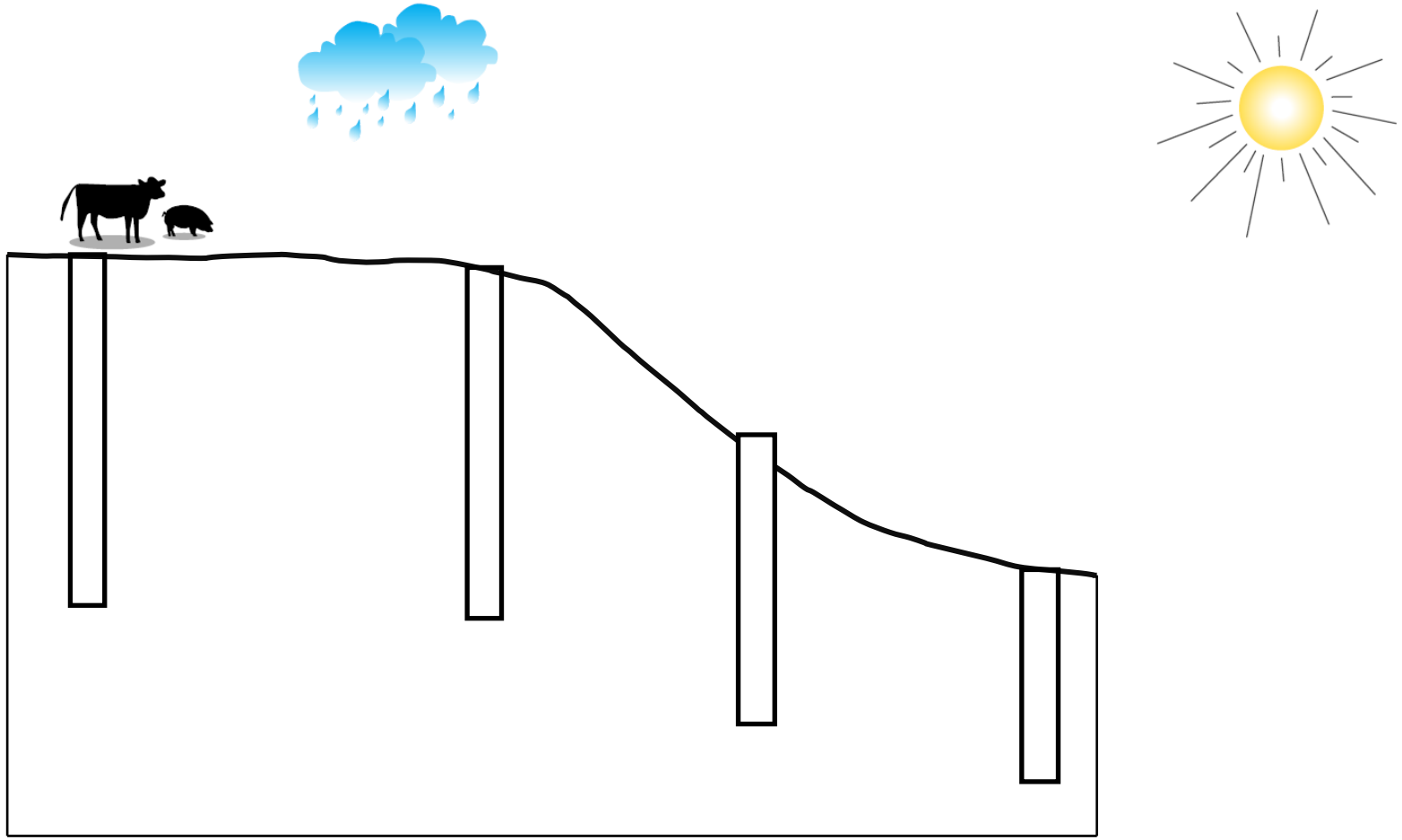
In an idea world…

Borehole drilling



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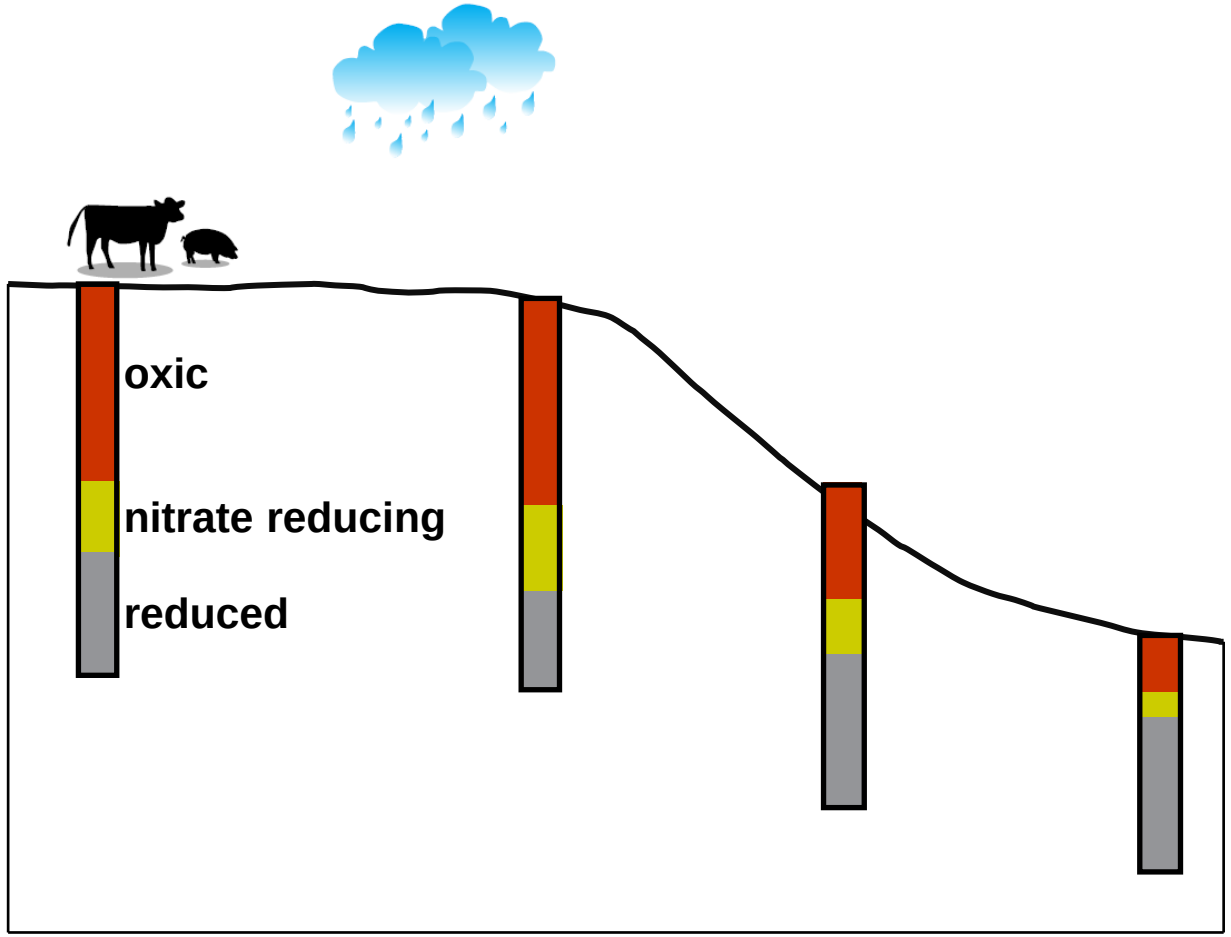
In an idea world…

Borehole drilling → Geochemical investigations



Redox interpretation from water chemistry and sediment colors

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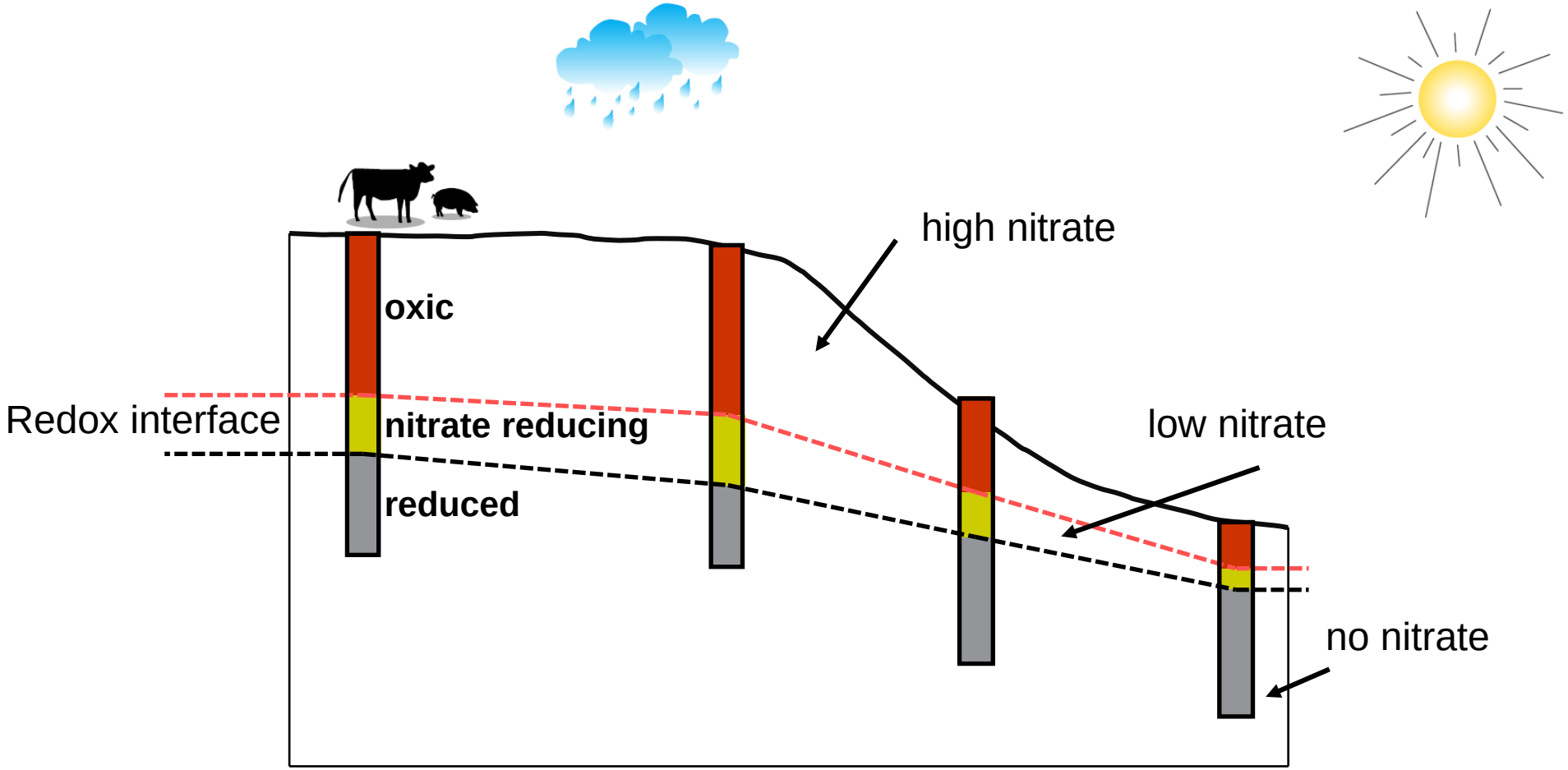
In an idea world…

Borehole drilling → Geochemical investigations → Spatial extrapolation



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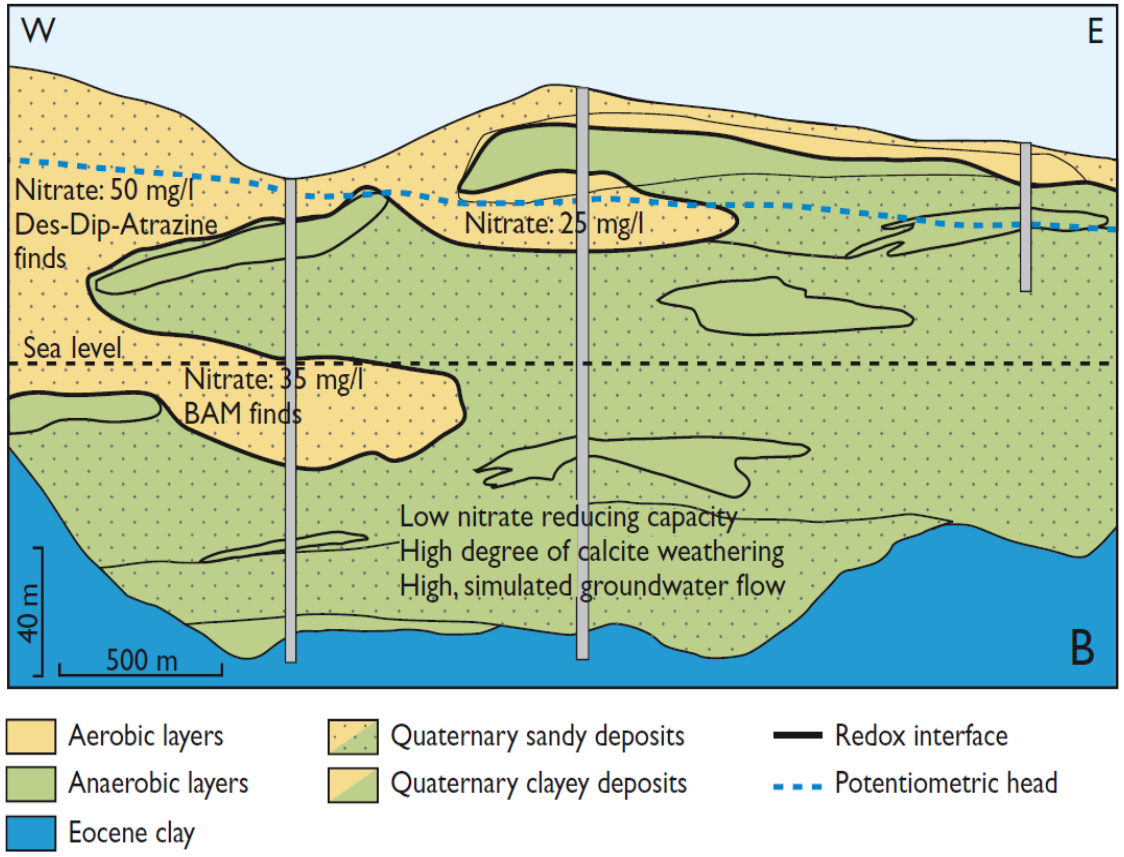
In the real world…

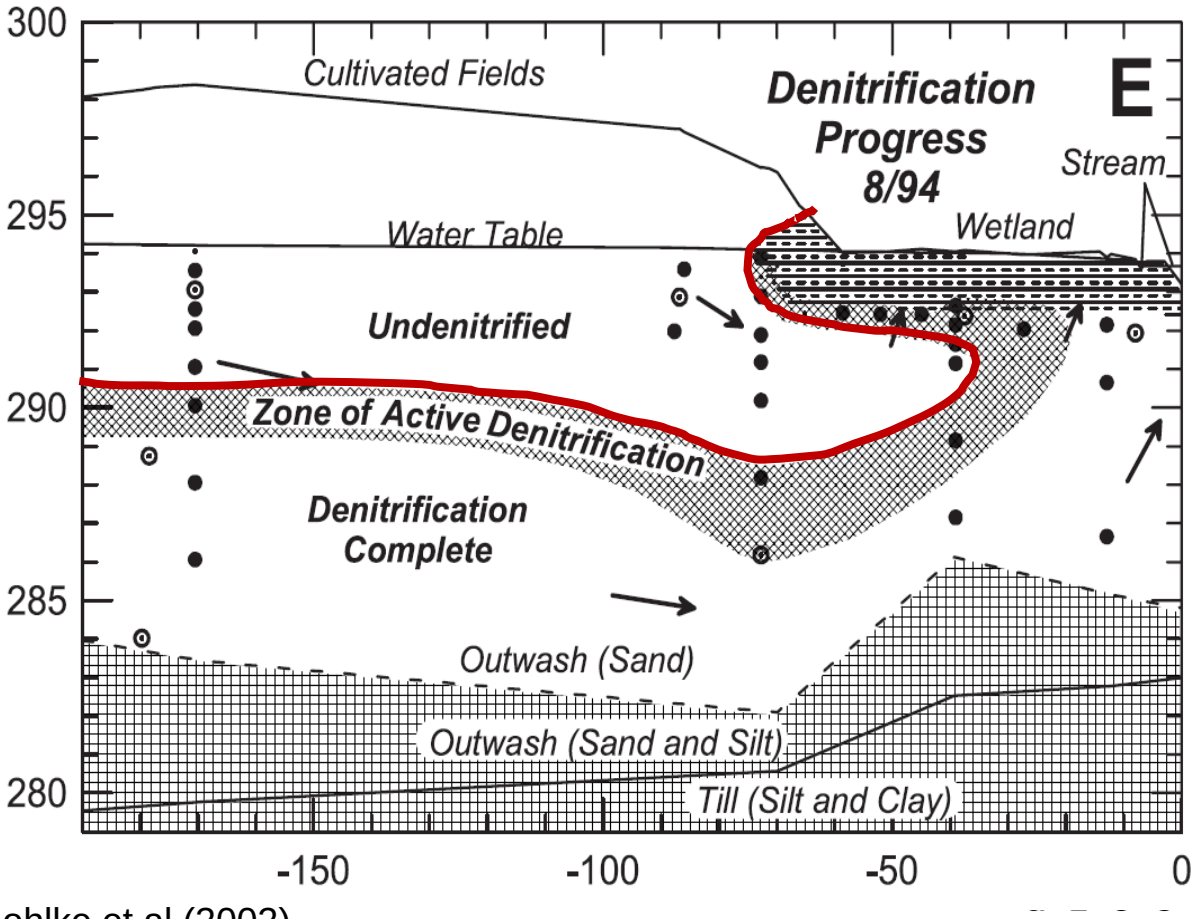
The redox interface is not a simple line that roughly follows the surface landscape.

Near Aarhus, Denmark



Hansen and Thorling (2008)

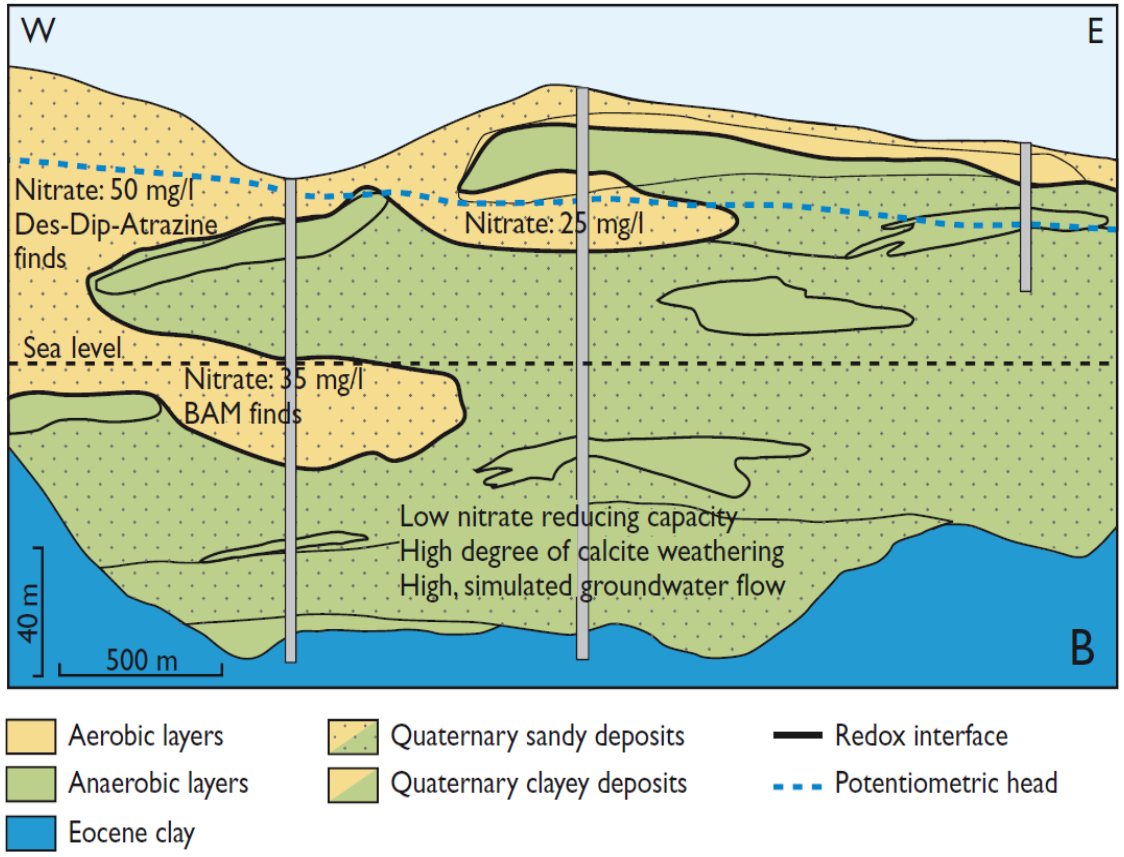
Minnesota, USA



Bohlke et al (2002)

Redox architecture

- Spatial information about the subsurface redox conditions in 3D dimension
- Underlying processes for the evolution of the redox architecture



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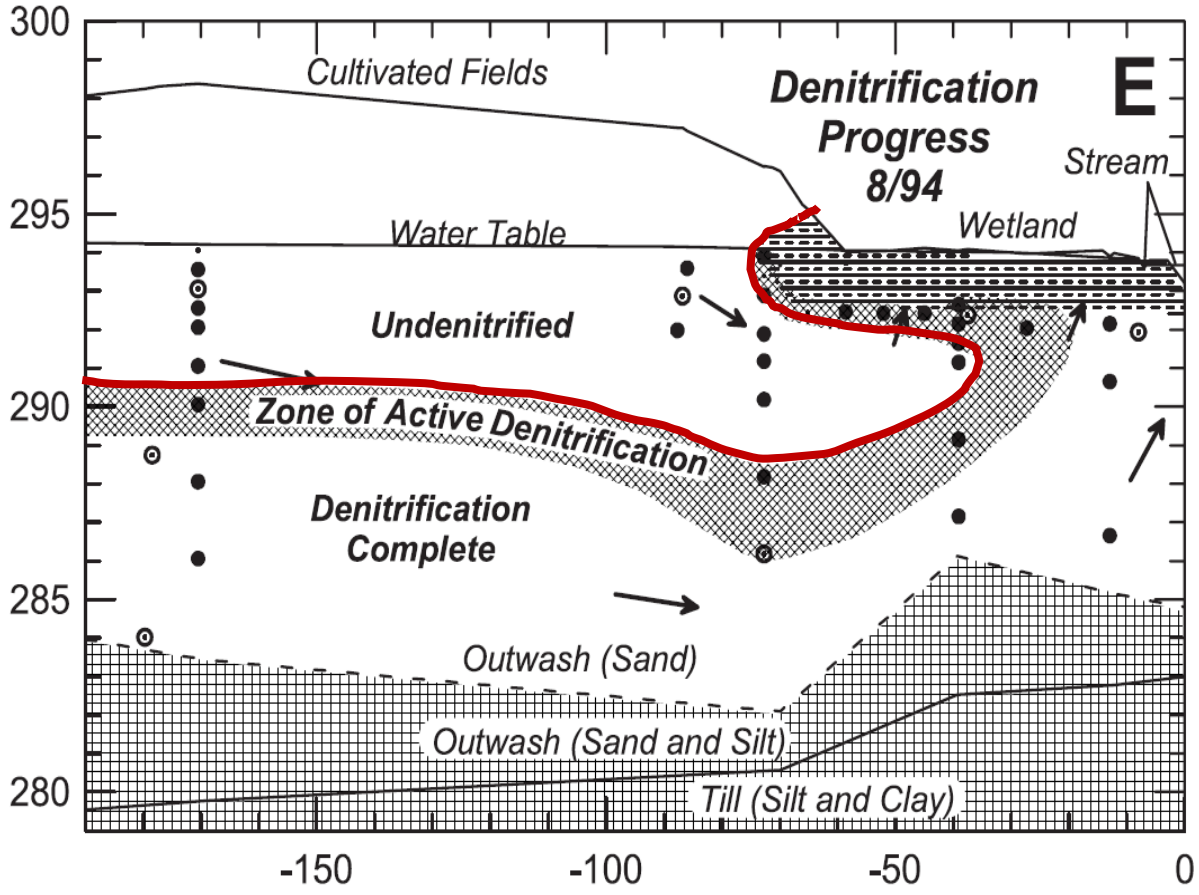


Bohlke et al (2002)

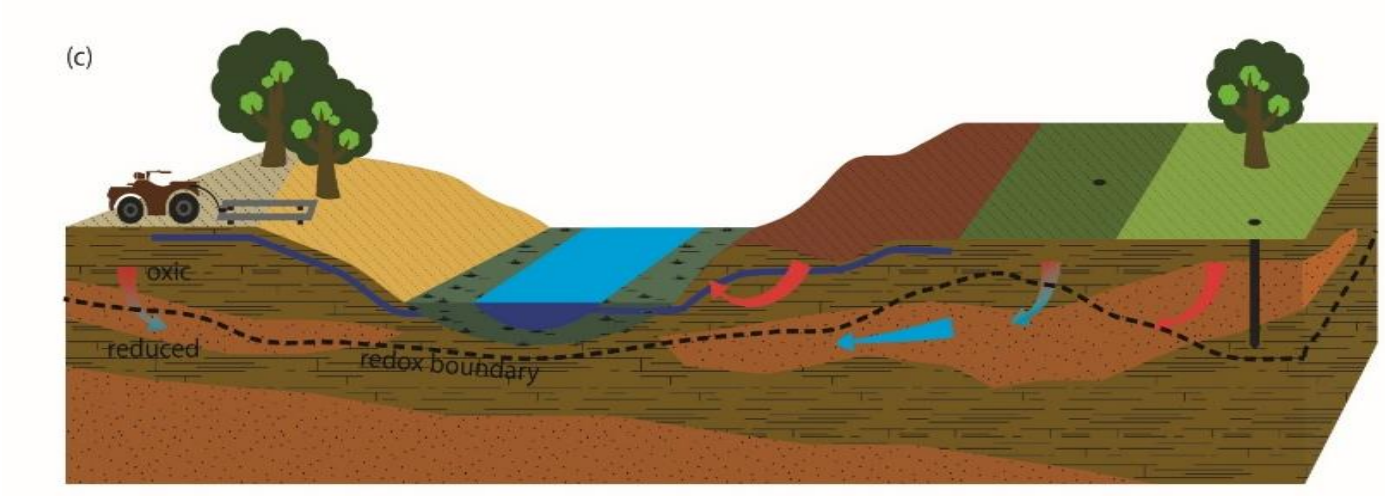
Controlling factors for the redox architecture in glacial landscapes

1. Oxygen influx since the Holocene (~ 11 kyr)

2. Nitrate influx since the Anthropocene

3. Amount and reactivity of the reduced materials (e.g., organic matter, pyrite)

4. Flow pathways



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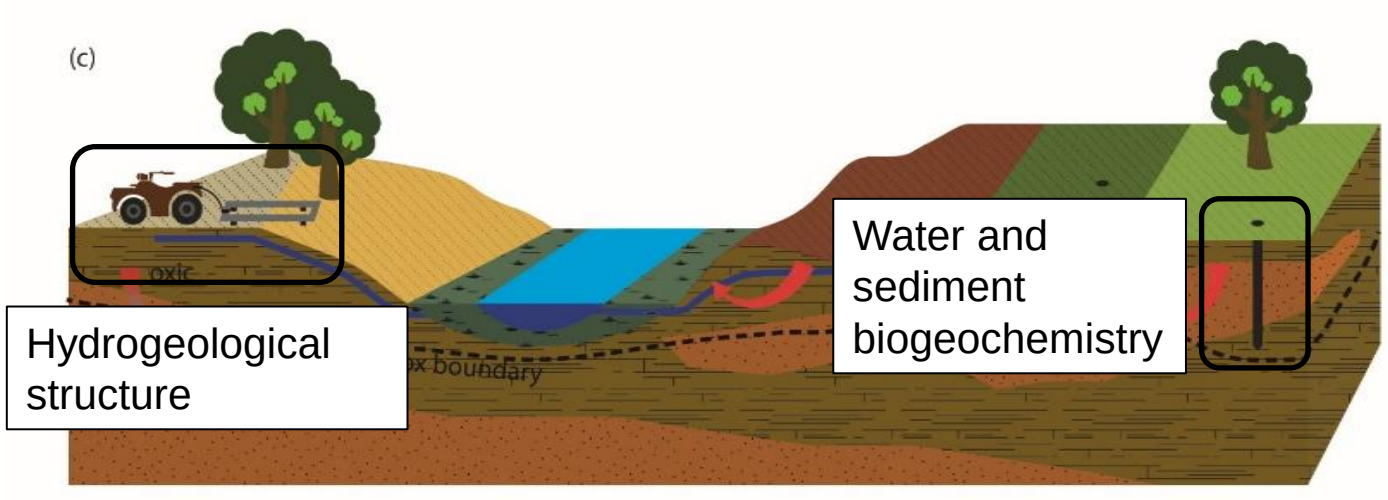

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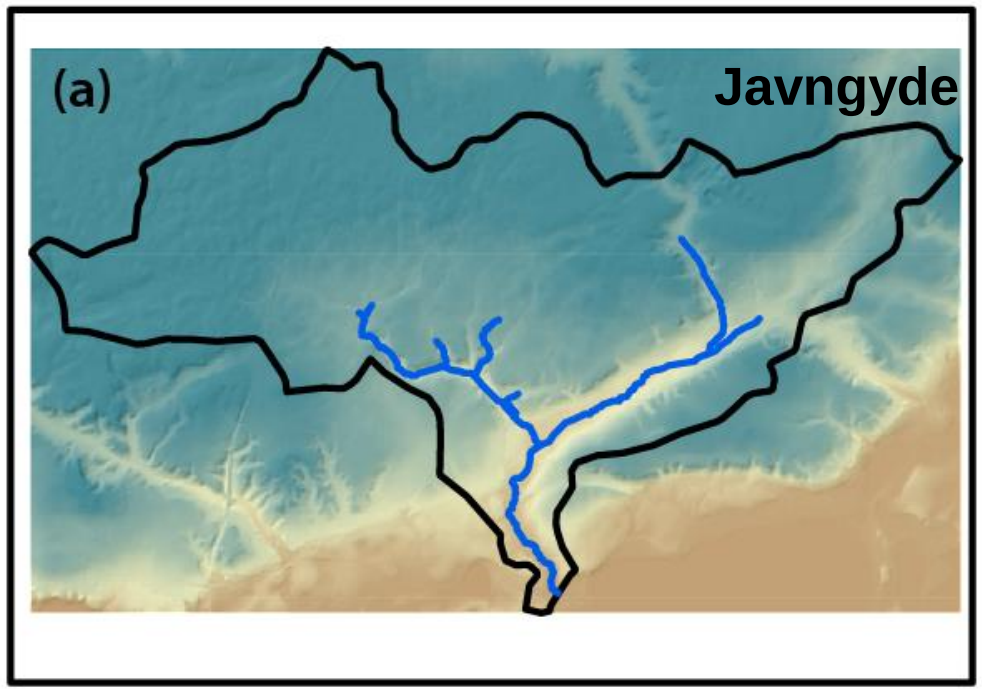
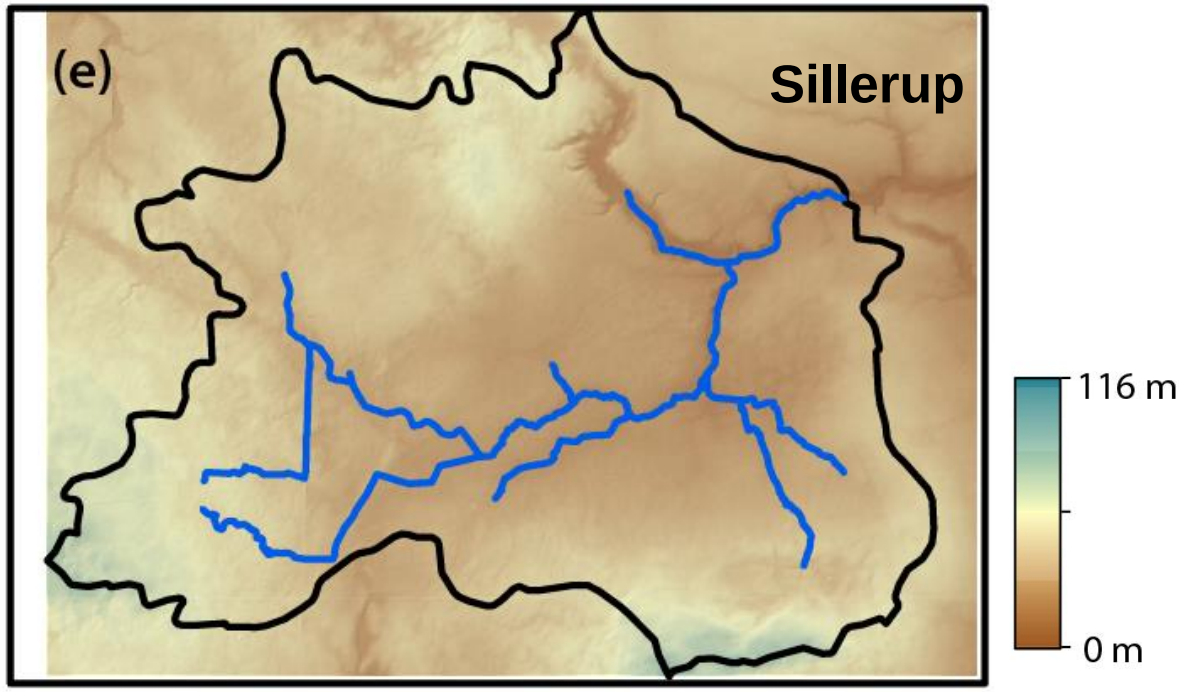
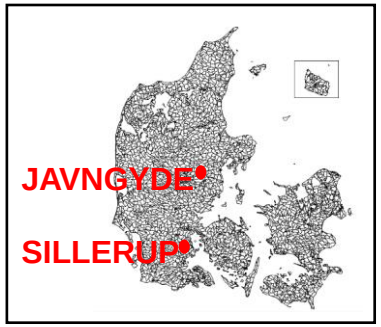
Redox architecture investigation:

Site overview



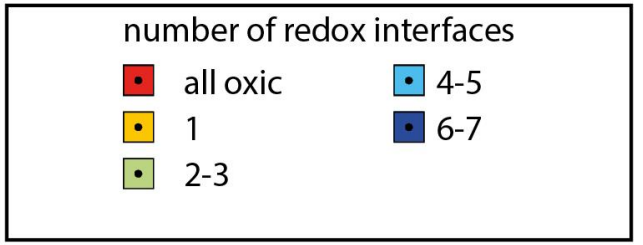


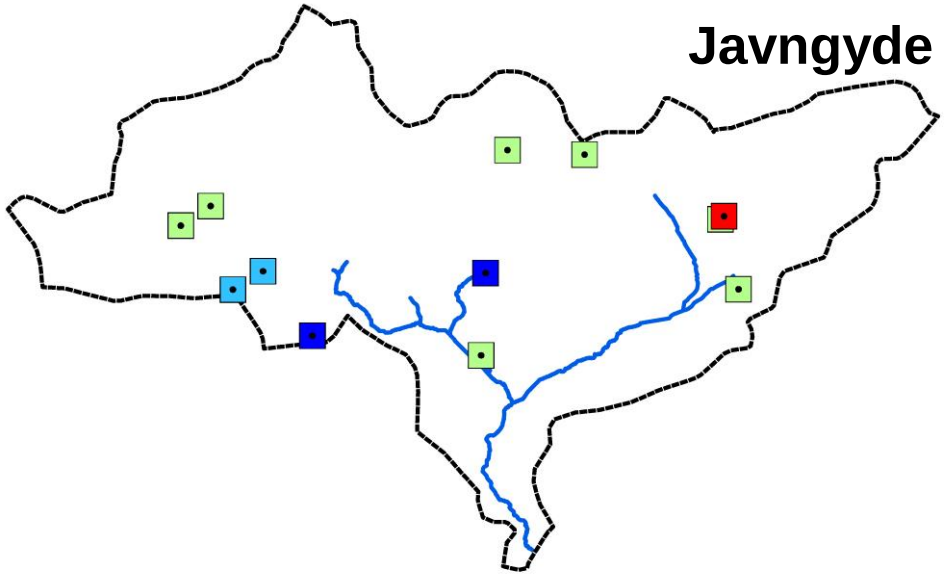
Top soil	Clay-till	Clay-till
Groundwater table	Deep in the west vs. shallow in the east	Shallow in the lowland and deep in the southern boundary
Nitrate in groundwater	Not detected to high (esp. private wells)	Not detected to low

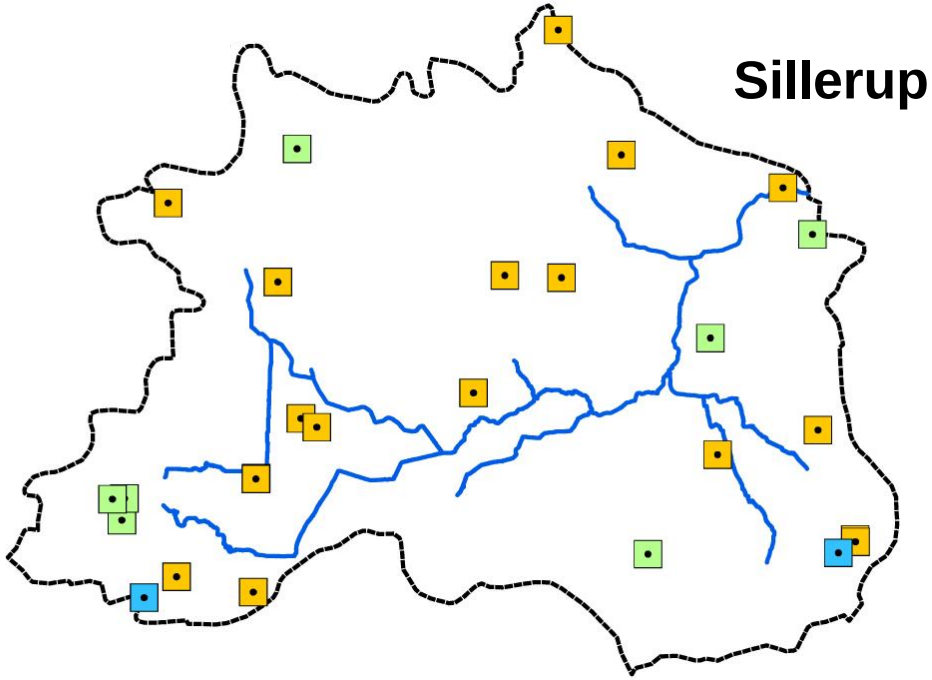


Redox architecture investigation:

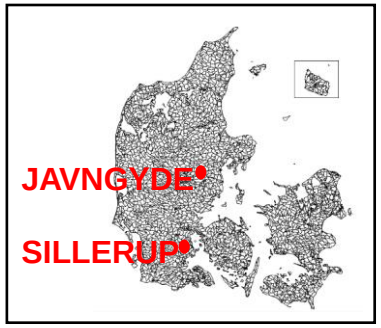
Sediment and water redox conditions







	Javngyde	Sillerup
Sediment colors	Multiple redox shifts	Mostly 1x redox shift
	Large spatial heterogeneity	Relatively homogenous pattern
Groundwater redox stage	oxic to Fe-reducing conditions	Fe-reducing to SO_4^{2-}-reduced conditions



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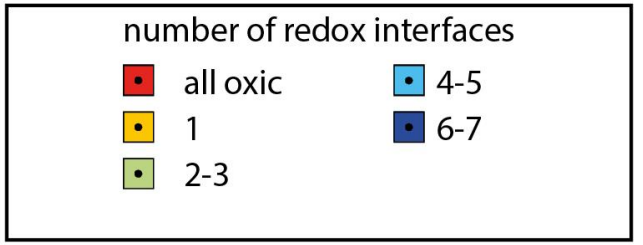

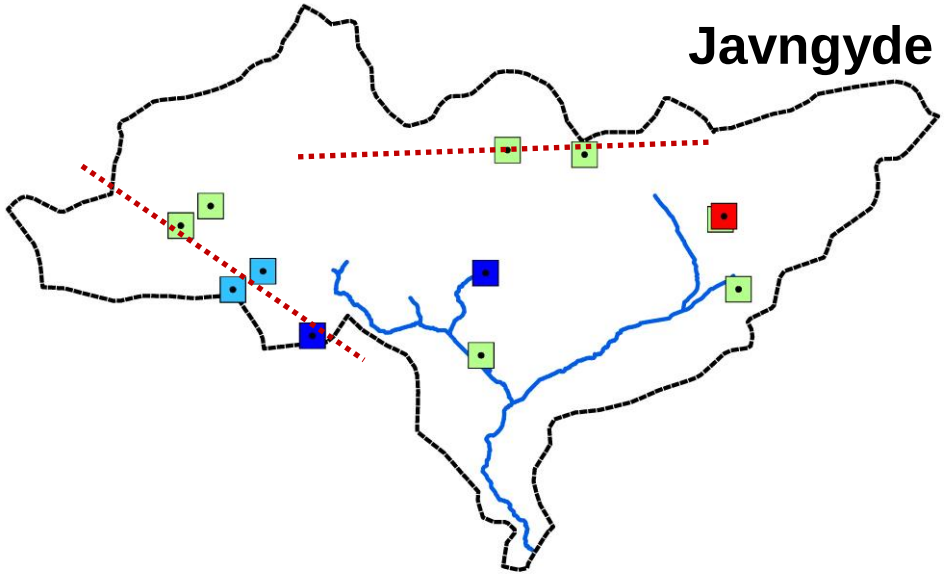

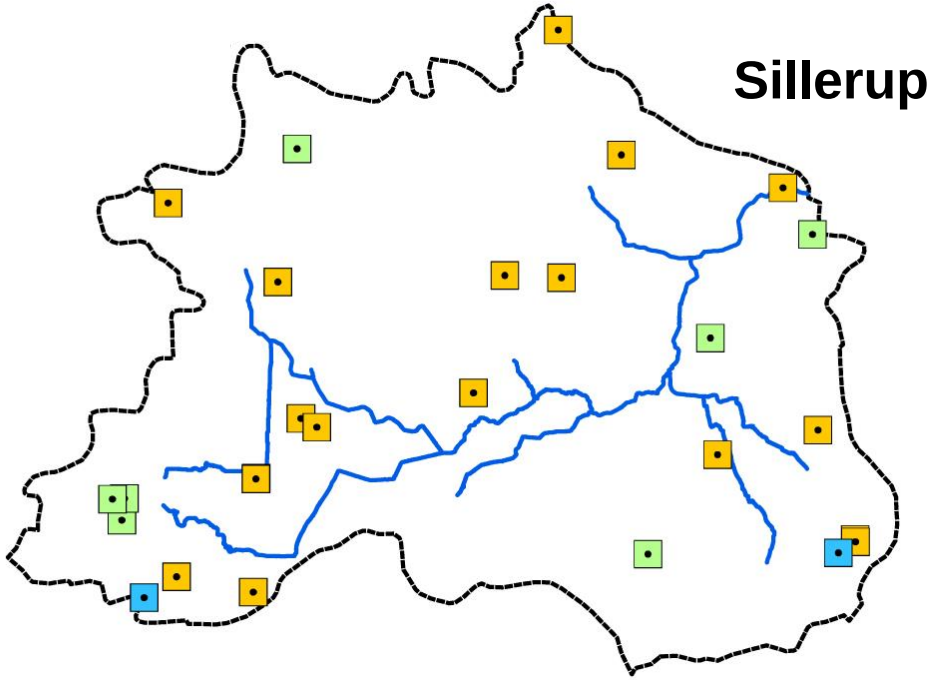

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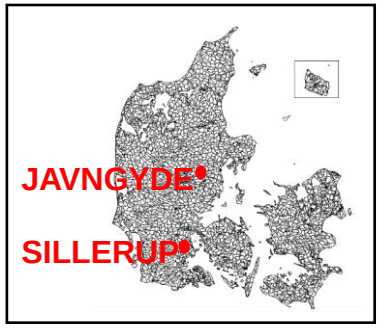
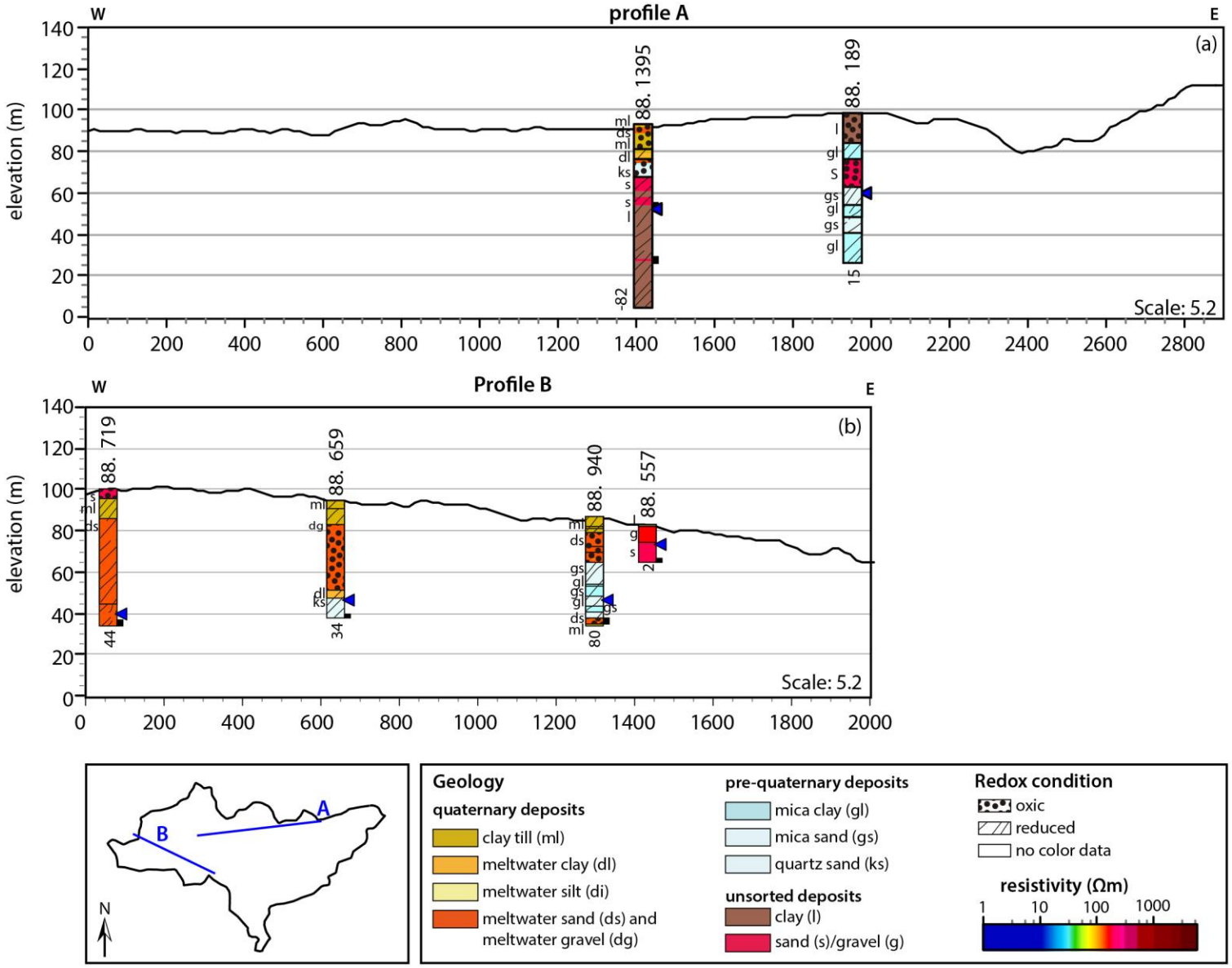


Redox architecture investigation

Javngyde

- Multiple redox shifts in all the wells.



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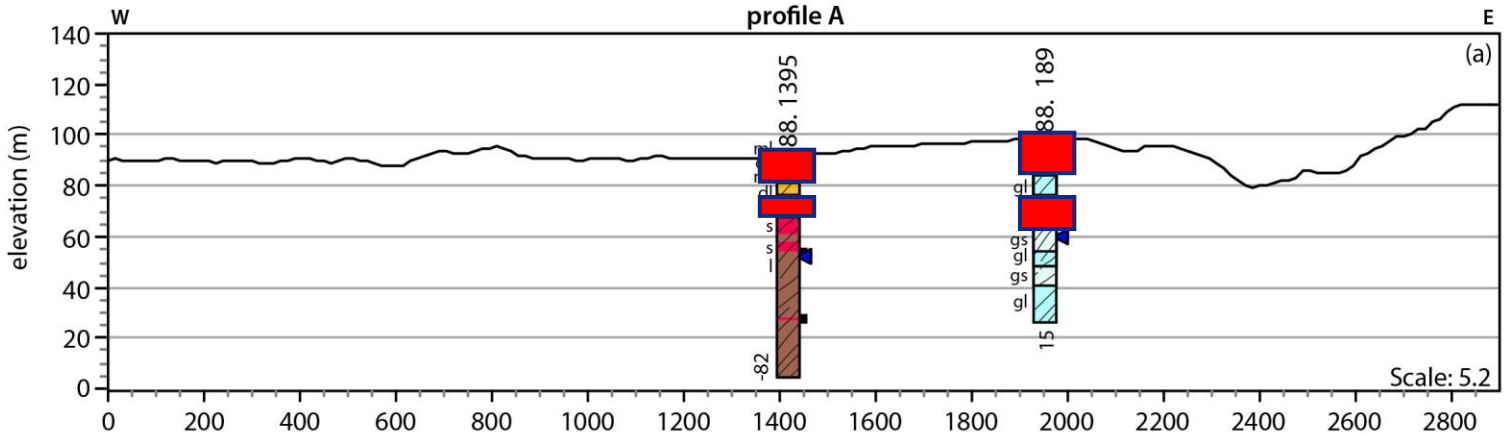
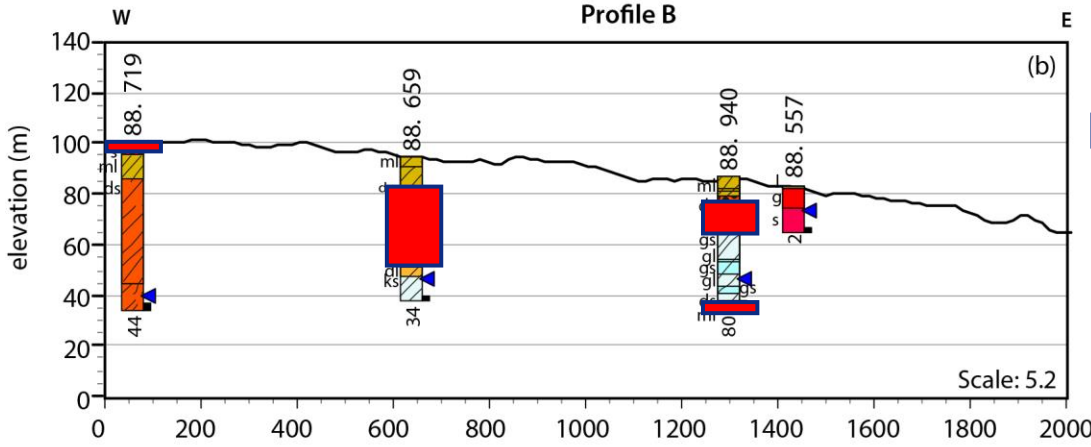
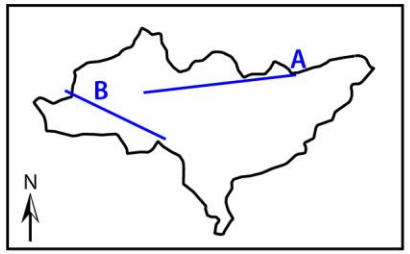
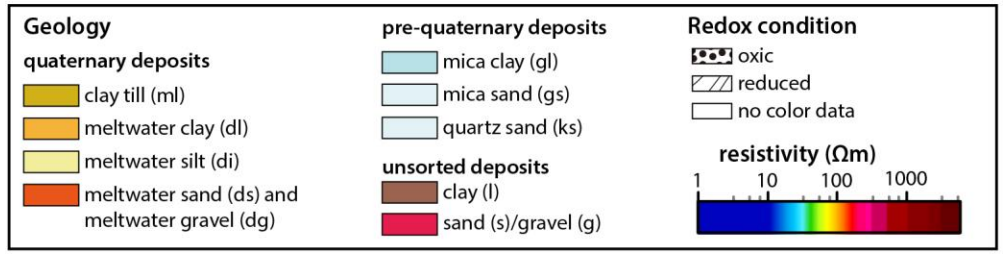




Sediments showing oxic colors



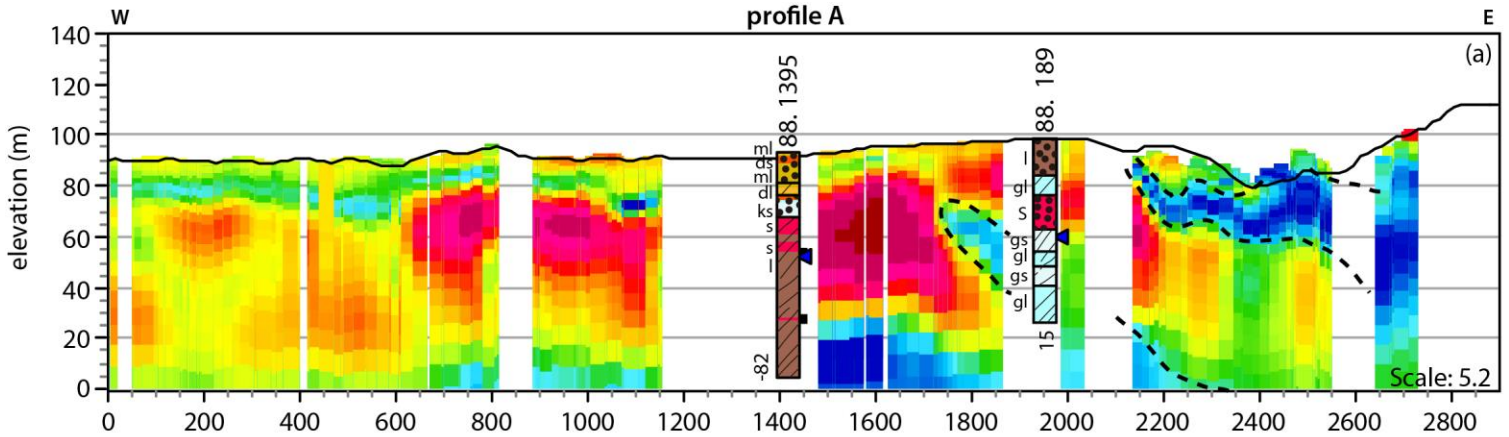


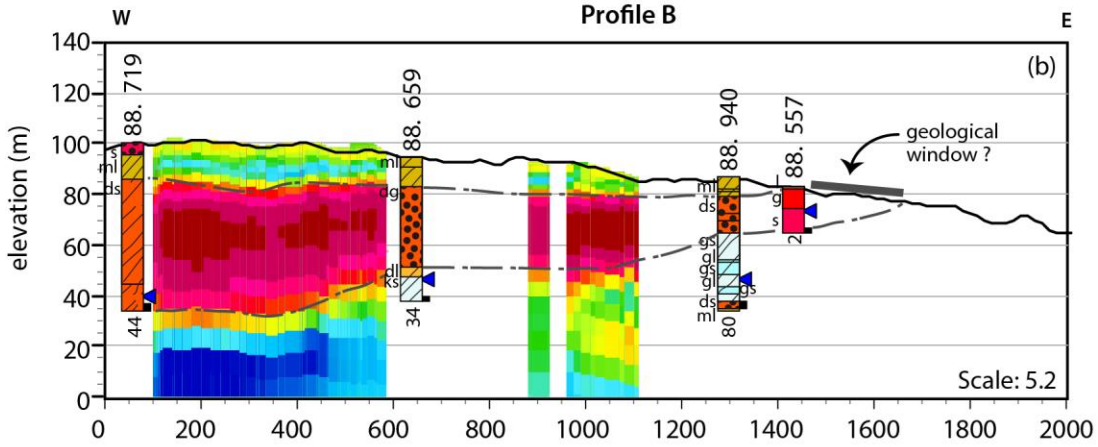
Redox architecture investigation

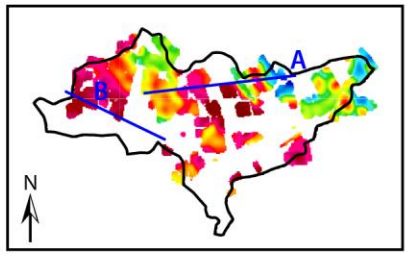
Javngyde

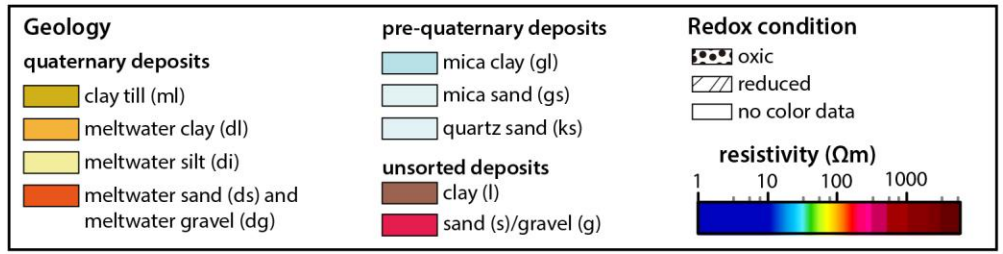
- Relatively homogeneous structure in the western part of the catchment

- Thrust structures in the eastern part of the catchment due to glacio-tectonics







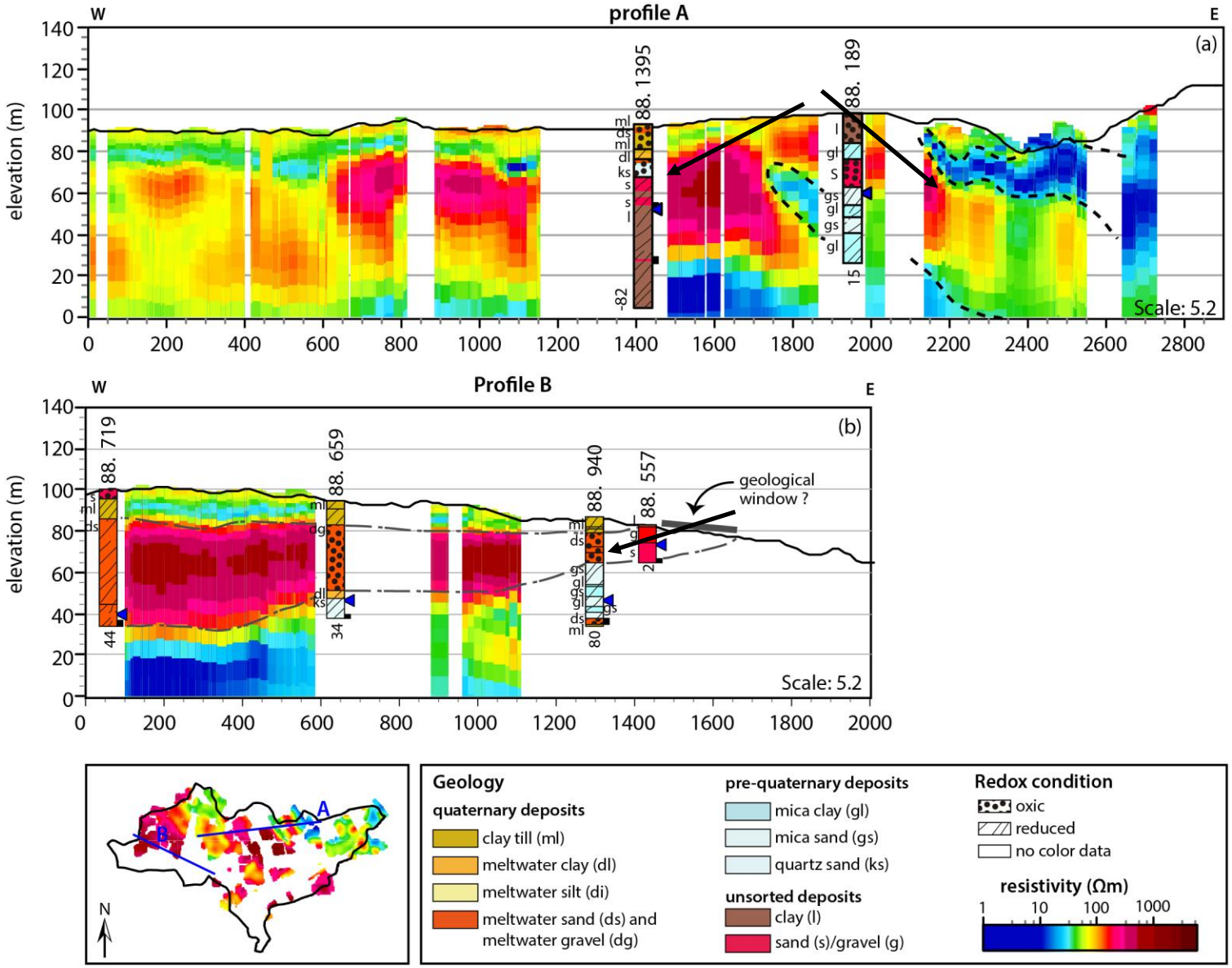


Redox architecture investigation

Javngyde

- Gas diffusion through the geological window in the western part

- Water and gas transport through the sandy layers between the thrusted clayey layers in the eastern part



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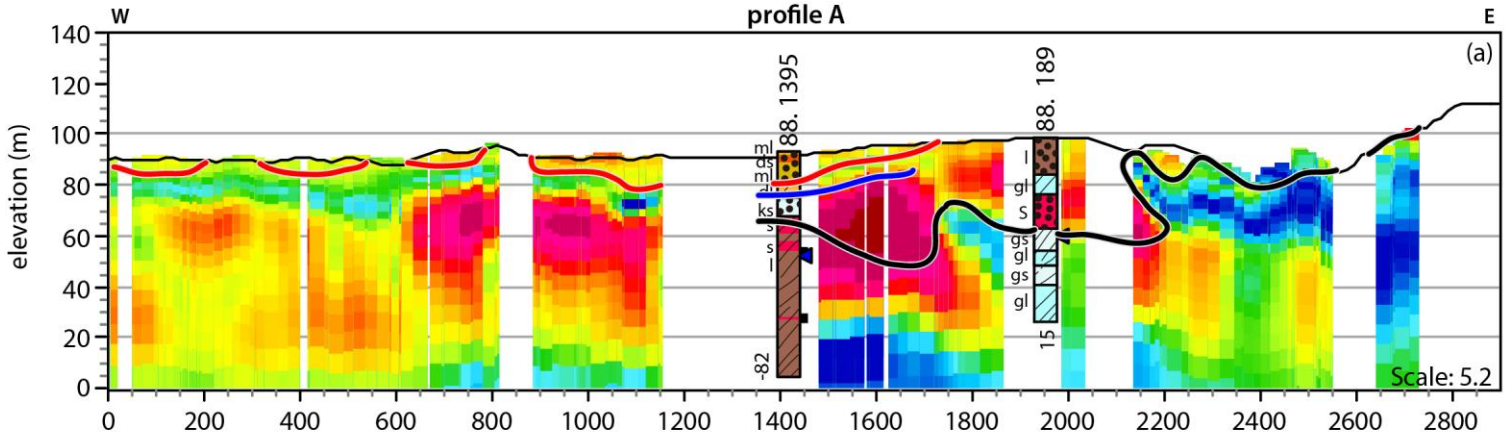
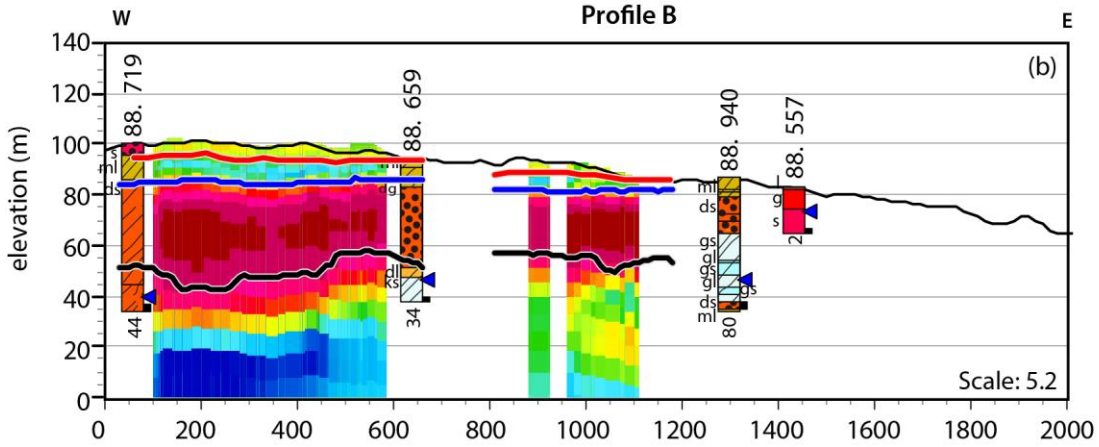
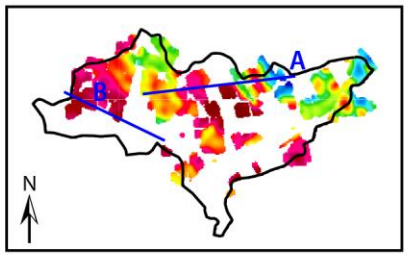


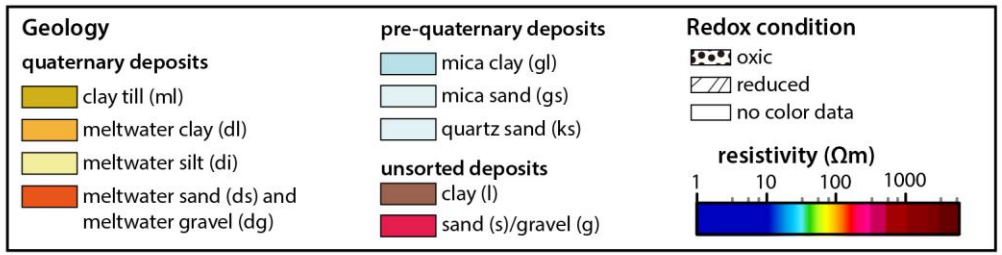


Reducing to reduced

Reduced to oxic

Oxic to reduced



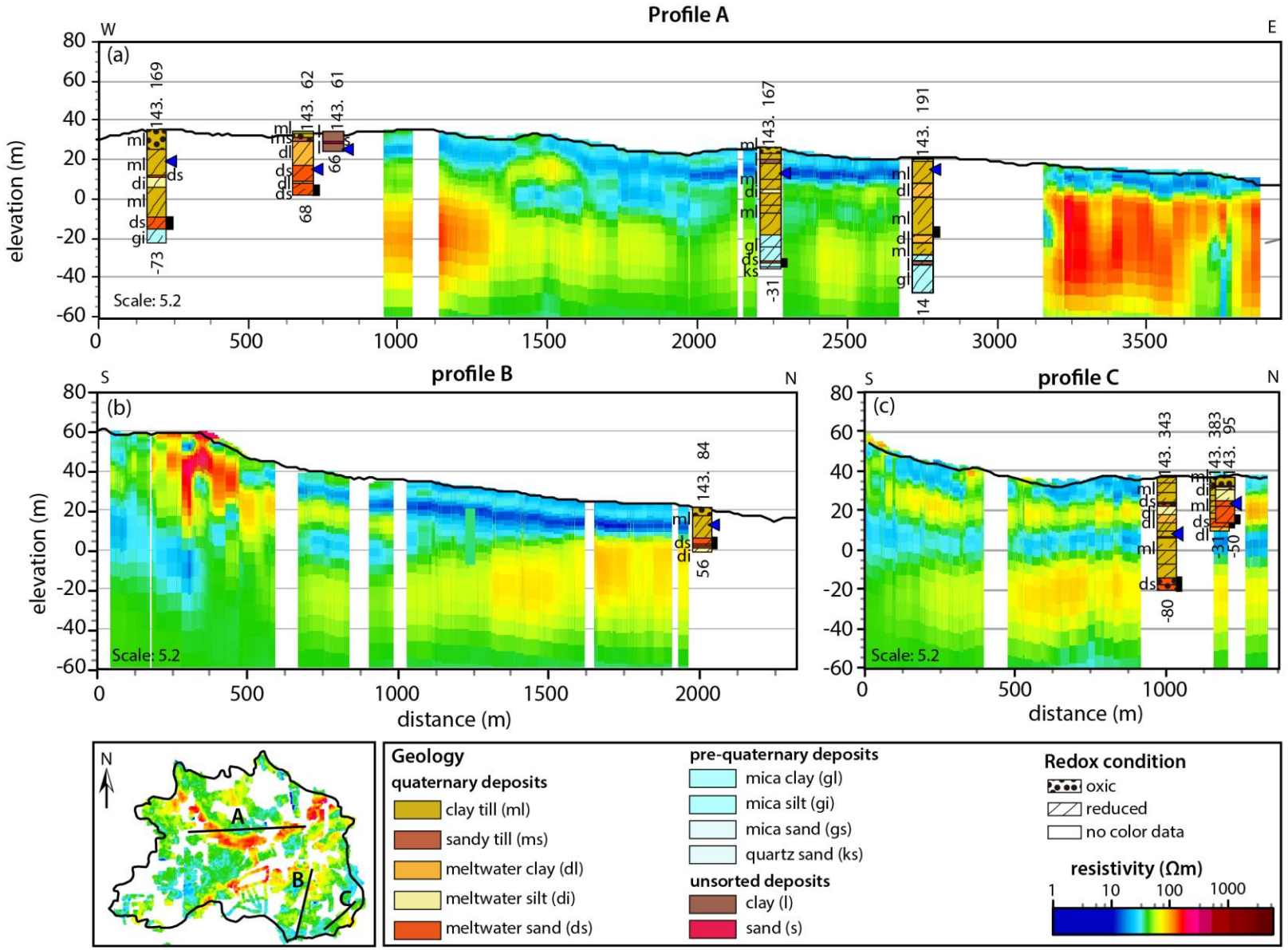


Redox architecture investigation

Sillerup

- Oxic to reducing colors at the shallow subsurface in the lowland area

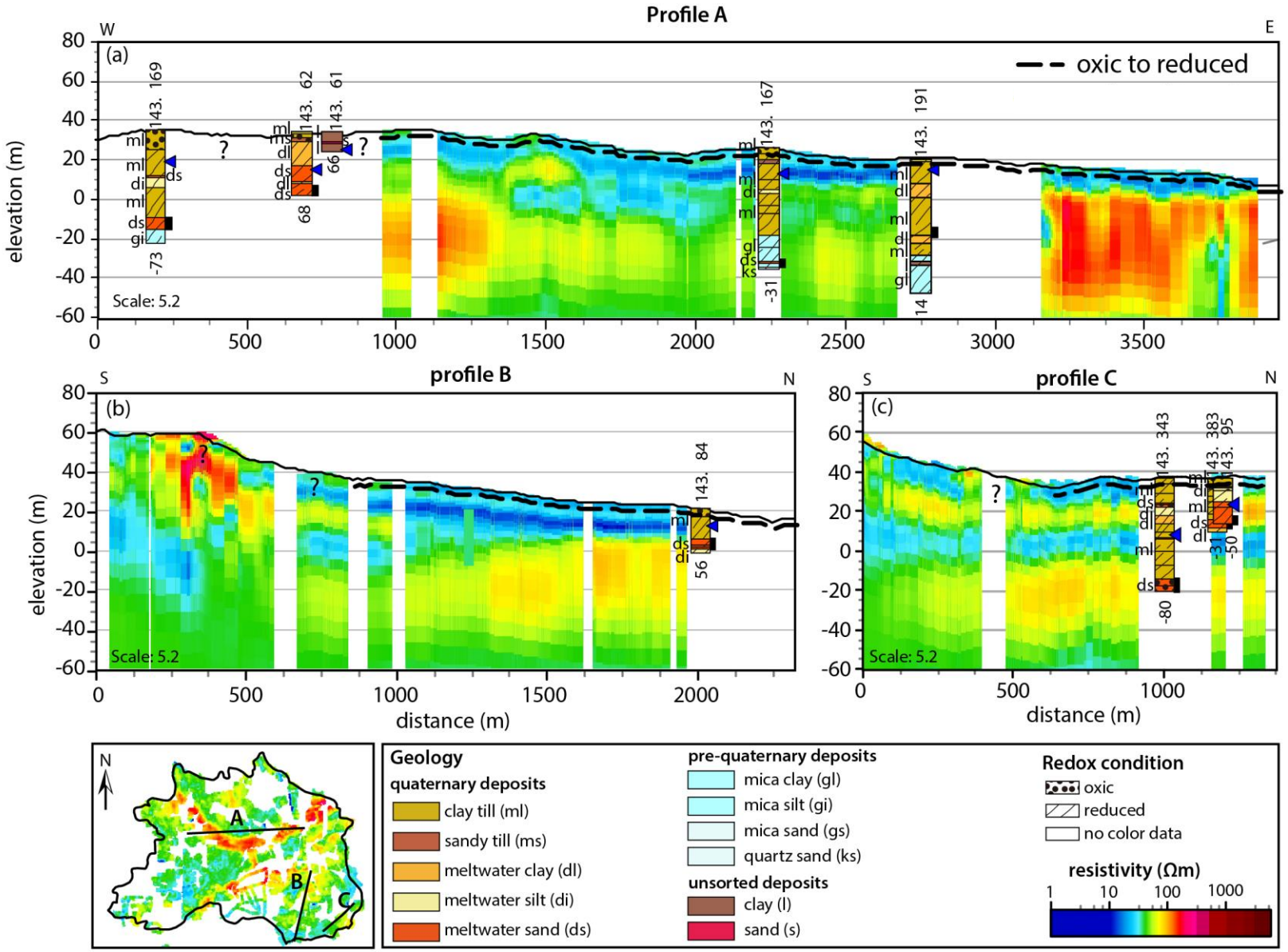
- Single redox interface



Redox architecture investigation

Sillerup

- Reasonable to extrapolate the observations
- Only to the lowland area
- Further research is needed for the higher elevation area



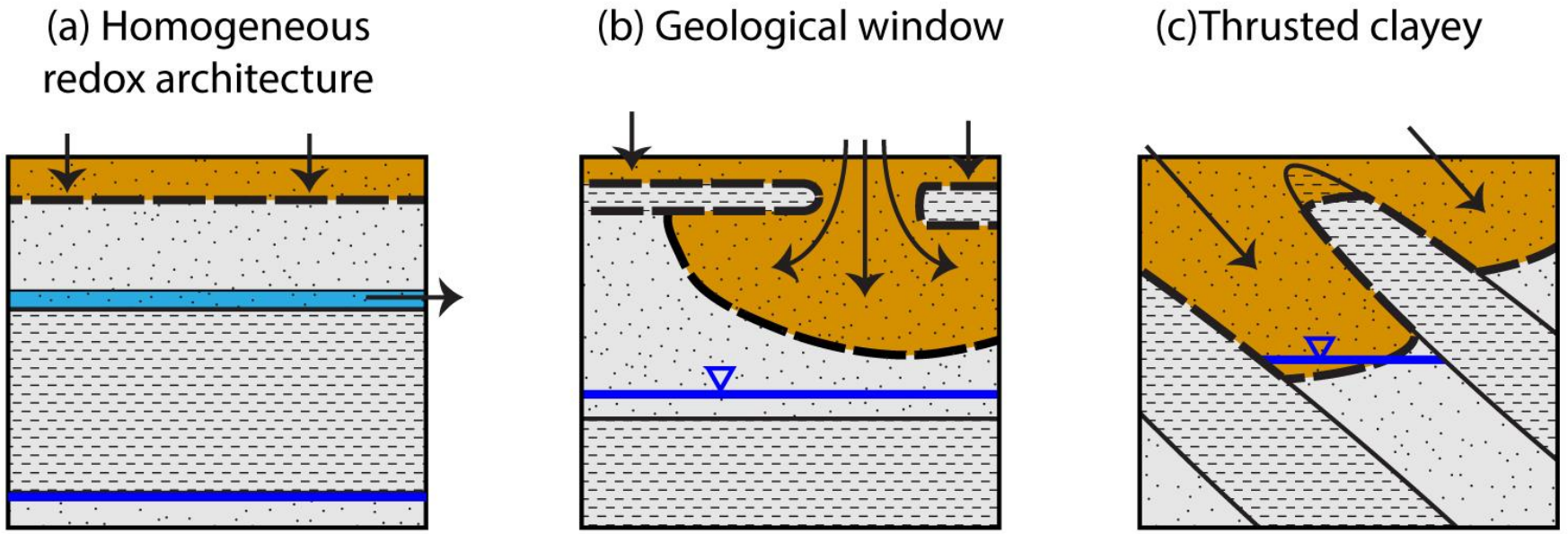
Summary

- tTEM measurements and borehole observations are complimentary in the redox interpretation.
  = Redox interfaces can be defined by synthesizing the tTEM and borehole observations

  = The spatial extent of the redox interpretations can be delineated.

  = Underlying processes for the redox condition evolution can be investigated.

- Three redox architecture types



Kim et al. (*in prep*.)

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